Waste Management 70 (2017) 3–12

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Reducing single-use plastic shopping bags in the USA

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ARTICLE INFO

Article history:
Received 27 September 2016
Revised 26 August 2017
Accepted 4 September 2017
Available online 19 September 2017

Keywords:
Sustainable materials management
Municipal solid waste
Extended producer responsibility
Plastic shopping bags
Source reduction
Recycling

ABSTRACT

In the USA, local governments have the primary responsibility to manage MSW. However, local governments lack the authority to explicitly shift costs or responsibility back onto the producer for specific problem wastes. A particularly problematic waste for local governments is the single-use plastic bag. In 2014, in the USA, 103.465 billion single-use plastic shopping bags were consumed. Because of their extremely low recyclability rate, plastic bags remain a significant source of land-based litter and marine debris and impair stormwater management systems. They also reduce the effectiveness of automated recycling systems. In response, local governments increasingly have adopted a variety of measures specifically intended to reduce the store-level consumption of single-use shopping bags in 5 major categories: bans, imposition of fees and taxes, establishing minimum product design of bags, requiring consumer education, and mandating retailer take-back programs. As of September 2017, there were 271 local governments in the USA with plastic bag ordinances covering 9.7% of the nation's population. The majority (95%) of the ordinances is a ban on single-use plastic bags; 56.9% of these bans also include a mandatory fee on paper and/or reusable bags. For the fee-based ordinances, the mode is $0.10 per bag; every tax/fee ordinance allows retailers to retain some or all the collected fee. As local governments continue to increase their actions on plastic bags, 11 states have enacted laws to prohibit local governments from regulating single-use plastic bags. Because of the success with single-use bags, local governments are also enacting similar ordinances on single-use expanded polystyrene consumer products and other single-use plastic products.

1. Introduction

In the USA, the federal government's role in municipal solid waste (MSW) management has been minimal; providing technical assistance and establishing minimum solid waste landfill criteria and regulating waste-to-energy facilities. State governments have a significantly broader role in planning and they generally establish the regulatory framework for MSW management, which typically includes the siting and permitting of solid waste management activities and facilities, establishing state-level recycling goals, imposing recycling requirements on businesses and institutions, and adopting state-level beverage container deposit/refund systems. It is local governments (e.g., counties, cities, towns, villages, and tribes) that have the primary responsibility for actually managing MSW.

Over the past decade, 33 states have enacted extended producer responsibility (EPR) laws to help shift the responsibility and costs away from local governments back onto the producers (Product Stewardship Institute, 2017). EPR laws have focused on electronic waste, mercury-containing products, rechargeable batteries, beverage containers, mattresses, carpet, packaging, and architectural paint. In addition to the cost-shifting goal of EPR, the goal is to encourage producers to internalize some of the end of life (EOL) costs of their product with the intent of encouraging the producer to redesign the product by reducing its mass and/or toxicity and/or improved recovery at the product's EOL (Lifset et al., 2013). EPR, however, is a state-level approach in the USA because local governments, unless specifically authorized by their state, lack the legal authority to adopt local-level EPR rules. Herein lies the conundrum, while the primary management responsibility of MSW resides with local governments, they lack the authority to enact EPR-based rules to reduce the quantity of MSW generated and disposed of within their jurisdiction. Local governments have, however, adopted a number of initiatives to decrease disposal of MSW including pay-as-you throw (unit-based pricing), curbside collection of trash and recycling, free recycling, single-sort recycling collection, education, community-based social marketing, organics collection, yard waste collection, and household hazardous waste collection. Although collectively these actions focus on increasing the capture of EOL materials through recycling, they do not explicitly focus on source reduction, which is essential to

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http://dx.doi.org/10.1016/j.wasman.2017.09.003
0956-053X/

reduce local government costs and to foster sustainable materials management.

In spite of the limitations on local governments' authority to implement EPR, in the USA, local governments increasingly are adopting an effective alternative. Most states in the USA do not prohibit local governments from banning, restricting, or discouraging the sale or use of a consumer product provided the product is: (1) considered to be problematic as MSW because it is difficult to recycle, expensive to recycle, is not recycled, or has no or insufficient market value; (2) causes significant local environmental impact such as a significant source of litter during use, collection, processing, and proper or improper disposal or it impairs stormwater management; and (3) viable and environmentally preferred substitutes exist. A consumer product that meets these criteria is the single-use shopping bag, especially plastic bags.

As local governments seek to reduce the environmental costs and impacts of specific products through the levying of taxes or fees, use restrictions, or outright bans, 11 USA states have adopted laws to explicitly restrict the ability of local governments to control bag usage including Arizona, California, Florida, Idaho, Indiana, Iowa, Michigan, Minnesota, Missouri, Texas, and Wisconsin. There are also unintentional impacts from state-level restrictions on local government. For example, California state law originally preempted local governments from charging a fee for plastic bags at checkout but did not prohibit bans (Romer and Tamminen, 2014). This partial restriction resulted in the adoption of 110 local plastic bag bans in California often coupled with a fee on paper bags. These 110 local government ordinances covered 43% of California's population, which gave rise to a citizen-ballot initiative passed in November 2016 that adopted the first ever statewide law in the USA banning the distribution of plastic single-use shopping bags and levying a $0.10 fee on paper bags.

This article first provides background information on single-use paper and plastic shopping bags. Then, the paper examines the local environmental and EOL management problems caused by single-use shopping bags. It next discusses the various options available to local governments to reduce or eliminate the generation of single-use bags. Finally, the paper examines the various approaches undertaken by 271 local governments in the USA to eliminate or reduce the consumption of single-use bags.

2. Single use shopping bags

Thin-film, single-use shopping bags are ubiquitous throughout the world. They are inexpensive, have a high strength to weight ratio, are waterproof, and have a multitude of uses (Lewis et al., 2010). Their primary intended purpose, however, is utilitarian; to convey purchased materials from the point of sale to a destination. The average life-span of a single use plastic bag is only 12 min (NSW EPA, 2016). Since the 1980s, consumers have been habitualized into expecting free, single-use plastic shopping bags (Sharp et al., 2010). Grocery stores generally are the single largest supplier of thin-film single use bags. In Montgomery County, MD, grocery stores accounted for 70% of all bags provided, non-food retailers 12%, retail super centers 8%, restaurants 3%, unclassified stores were 7%, and wine and liquors stores were <1% (Montgomery County, 2016). In the USA, the mean grocery shopper trips per week is 1.6 (FMI, 2016).

Single-use plastics bags are primarily made from fossil fuels. High Density Polyethylene (HDPE, resin identification code #2) is the primary material for thin-film, single-use bags (e.g., singlet bags) used primarily at grocery stores, convenience stores, and takeout restaurants. Based on a survey by Verghese et al. (2006), single-use HDPE bags provided by grocery and department stores generally range from 0.7 to 1.75 mil in thickness and include handles. The inclusion of handles often differentiates shopping bags from other single use plastic bags such as those used to carry materials within a store to the cashier/checkout (e.g., barrier bags) including bags for produce, meat, fish, and bulk foods and for dry cleaning and product packaging. Low Density Polypropylene (LDPE, resin identification code #4) bags (e.g., boutique style bags) generally are imprinted bags with plastic or fiber handles and generally range from 2.25 to 3 mil in thickness and are provided by retailers selling higher value or specialty goods (Verghese et al., 2006). Paper bags are generally made of kraft paper, including post-consumer recycled paper, and generally weigh about 43 gm. Standard paper bags have 50% more carrying capacity than standard plastic shopping bags (Sapphos, 2010).

2.1. Per capita consumption of bags

Precise data on the per-capita consumption rate of bags are difficult to find in part because many businesses treat this data as proprietary information or simply do not track per-customer bag consumption. As shown in Table 1, a range of published per-capita consumption rates of bags exists for various reporting years prior to the implementation of a reduction-based ordinance; however, some sources have reported plastic bags only or separately or all single-use bags combined. (Note nearly all of data in the table below are estimated.) The variation in per-capita consumption of single-use bags is influenced by multiple factors at the point of sale. Based on a survey by Sapphos (2010) in Los Angeles County, CA, customers used more plastic single-use bags when they are available compared to paper bags. For example, at traditional grocery stores, customers used single-use plastic bags 96% of the time compared to 2% paper and 2% reusable (Sapphos, 2010). The authors also report different bag use data at non-traditional grocery stores (large specialty or "gourmet" stores) with a reputation for attracting shoppers with higher incomes. In those non-traditional stores, only 4% of the bags were plastic followed by 18% reusable and the highest amount being paper at 78% (Sapphos, 2010).

The US International Trade Commission (USITC, 2016) estimated the national annual per capita consumption of single-use plastic shopping bags in 2014 for the USA to be 319.5, which includes bags consumed at grocery, drug, convenience, department, specialty retail, discount stores, and restaurants. (The total USA consumption in 2014 was 103.465 billion plastic shopping bags.) In the USA, since 2009, there has been a 6.8 percent increase in consumption of plastic bags although the annual per capita consumption rate has steadily decreased since 2010 (USITC, 2016). And, the future demand for plastic shopping bags is expected to continue to decline primarily because of increased use of reusable bags and the increased imposition of local bans, fees, and taxes (USITC, 2016).

2.2. EOL impacts from single use bags

2.2.1. Low recycling rates

Although the precise national recovery rate for single-use bags is not known, the recycling rate of plastic bags is very small. According to the US Environmental Protection Agency (US EPA, 2016), the 2014 EOL recovery rate for all (HDPE and LDPE combined) plastic bags, sacks, and wraps combined was 12.3%, which represents a decrease of 1.2% from 2013 (US EPA, 2015). Although the US EPA provides national annual data, their data is based on predictive modeling and not measurement through waste characterization studies and thus is known to significantly underestimate generation rates and overestimate recovery rates (Powell et al., 2016; Wagner and Raymond, 2015; Van Haaren et al., 2010). In addition to the inaccuracy of US EPA's data, the amalgamation of

Table 1
Various estimates of per capita, annual consumption of single-use shopping bags.

	Location	Pre-action consumption	Notes	Source
Country	Australia	303	HDPE bags only	Cain and Oke (2008), Montoya (2013)
	Ireland	328	Plastic bags only	Rucker et al. (2008)
	Israel	300	Plastic bags only	Ayalon et al. (2009)
	Japan	360	Plastic bags only	Ohtomo and Ohnuma (2014)
	USA	319.5	Plastic bags only	US ITC (2016)
US State	California	703	Plastic bags only	AECOM (2010)
	Maine	442	320 plastic bags + 122 paper	Wagner (2016)
	Washington, DC	465	Plastic and paper bags	AECOM (2010)
US Local	Aspen, CO	398	Plastic and paper bags	Brendle (2012)
	Austin, TX	335	Plastic bags only	Waters (2015)
	Boulder, CO	342	Plastic and paper bags	Brendle (2012)
	Evanston, IL	471	428 plastic bags + 43 paper	Evanston (2011)
	Los Angeles County, CA	600	Plastic bags only	LA County (2007)
	Santa Monica, CA	552	Plastic bags only	R3, 2010
	Seattle, WA	630	511 plastic bags + 119 paper	Herrera (2008)

residential bags and sacks with industrial and commercial film and wraps makes the identification of an accurate recycling rate specifically for consumer-generated plastic shopping bags extremely difficult. In contrast, based on waste characterization studies, the recycling rate of plastic shopping bags in Illinois was 1.5% in 2009 (IDECO, 2009) and in California, 3% (CalRecycle, 2010).

As discussed below, the low recycling rate for plastic bags is a function of multiple factors. There are three primary methods for the collection of EOL single-use bags: dedicated collection sites, such as an in-store recycling program; through the curbside collection of commingled recyclables; or drop-off of commingled or segregated recycling at municipal transfer or material recovery facilities. For stores that collect segregated EOL bags, large stores or chain stores can have sufficient volume to recycle collected EOL bags while small or medium size stores and independent stores may not have sufficient volume (MSPO, 2010). For plastic bags collected as commingled recycling at the curbside or municipal transfer facility, the bags must be separated at a material recovery facility (MRF) to maximize their economic value. In general, the more segregation of commingled recycling that occurs, the higher the economic return of the segregated materials; however, there is a point of diminishing return where the cost of segregation exceeds the value of the segregated materials (Morris, 1991). Because of the difficulty and thus cost of segregating plastic bags, allowing them to remain with other recyclable materials can contaminate the target material thereby reducing its market value. As noted by Rogoff and Ross (2016), the removal of difficult to recycle, non-target materials from the wastestream has the added benefit of reducing the overall recycling costs and increasing the value of the end product. There is an additional cost with plastic bags. While they are not readily separated at MRFs, they are in fact an economic liability because they often get snagged or trapped in automated sorting equipment causing restrictions or breakdowns necessitating daily removal, often by hand (Wagner, 2016; Brendle, 2012). The net economic value is the driver in recycling plastic bags, which takes into account the costs of collection, segregation, recovery, baling, transporting, and their impact to automated sorting equipment. From an economic perspective only, recovering plastic bags that have been comingled with other recyclables does not make sense if costs exceed the revenues. While most municipalities do not "accept" plastic bags for recycling, if they are received at a MRF, a common practice is to include them with commingled plastics (resin identification codes #3 through #7), which is the lowest grade plastic that has minimal positive, or can have negative value thereby costing the municipality to sell these plastics as recycling (Wagner, 2016).

It is important to note that plastic bags are often reused prior to their discard. In 2007, 51% of plastic carryout bags in California were reused; 55% of this amount was reuse for trash bags (AECOM, 2010). Based on a survey by Prendergast et al. (2001), plastic shopping bags were reported to be reused 1.6 times and paper shopping bags were reused 2.7 times. Thus, while they are single-use bags, nearly half the plastic bags were reused prior to discarding, which is an important step in the waste management hierarchy.

2.2.2. Contribution to litter

Plastic shopping bags become litter through intentional discard as litter (KAB, 2009) and through their escape during collection, transportation, recycling, or disposal as trash or recycling. Bags readily become litter due to their aerodynamic/ballooning feature allowing them to easily become airborne from natural wind and wind created by passing vehicles (Wagner and Broaddus, 2016). Plastic bags are likely to inflate and then be dispersed by the wind even at low wind speeds and will travel considerable distances until they snag (Verghese et al., 2006). The ease with which bags can flyaway is a primary cause of them becoming land-litter and eventually marine debris. Plastic bags are often the number one litter/flyaway issue at landfills (Brendle, 2012; FDEP, 2010). To control landfill-generated litter, portable litter fences are installed near a working face of landfills to trap blowing litter necessitating daily cleaning to remove trapped litter to reduce wind damage to the fences (Christensen, 2011; Martel and Helm, 2004). Thus plastic bags are an item that can easily become litter on its way to or after proper collection and disposal (Godman, 2013). Plastic is especially problematic because if its longevity in the environment. Along the Anacostia River shoreline in Maryland, plastic bags constituted 33% of total items found (MWCOG, 2009). Los Angeles conducted a waste characterization of stormwater catch basins and found that plastic bags were 25% by weight and 19% by volume of the trash collected from the catch basins (LA County, 2007).

When plastic litter enters surface waters, storm drains, and the marine environment, its impact becomes far more significant. For example, Washington, DC, and Montgomery County, Maryland, are subject to a federal rule regarding the discharge of trash into the Anacostia River, an interstate watershed that is a tributary to the Potomac River that flows into the Chesapeake Bay and finally into the Atlantic Ocean. The Anacostia River is only one of a few surface waters in the USA subject to a Total Maximum Daily Load (TMDL) rule governing the discharge of trash in surface waters of the USA. Issued under section 303(d) of the Clean Water Act, a TMDL establishes a maximum, science-based amount of a pollutant(s) to be discharged into a specific waterbody or section of a waterbody to maintain specific water quality standards. The primary impairment of the Anacostia River is plastic trash and debris (US EPA, 2010). Based on multi-year surveys, the top trash category

based on quantity of items in tributary streams of the Anacostia River was plastic bags and they were the fourth top trash category item counted in stormwater drain inlets (US EPA, 2010).

In 2010, from 4.8 to 12.7 million MT of plastic litter entered the marine environment from the land (Jambeck et al., 2015). The input of plastic into the marine environment far exceeds its removal because of plastic's buoyancy and longevity as plastic can potentially last hundreds to thousands of years (Cózar et al., 2014). Of paramount concern in the marine environment are microplastics, which are created primarily through fragmentation of larger pieces or articles of plastic. Fragmentation occurs through multiple processes including wave and tide action and photo-oxidation.

Plastic bags are one of the most common components of marine plastic litter (Green et al., 2015). In 2015, the Ocean Conservancy's International Coastal Cleanup counted plastic bags (6th) and plastic grocery bags (8th) among the top ten most frequent litter items collected throughout the world (Ocean Conservancy, 2016). Plastic bags can negatively impact marine organisms. According to Gall and Thompson (2015), at least 690 marine species encounter marine debris with negative impacts to many including entanglement, ingestion, and death. Plastic bags also impact benthic environments as they are known to cover the ocean floor (Kühn et al., 2015) with significant impacts to invertebrates inhabiting the sediment Green et al. (2015).

Cleaning-up marine litter from the open ocean is not currently feasible; prevention is the only successful approach to manage the problem (Jambeck et al., 2015). In contrast, cleaning up land-based litter is feasible, but can be a significant expense for local governments. Based on a study by Wagner and Broaddus (2016), the estimated cost of labor alone to collect each piece of litter from curbside recycling collection ranged from $0.17 to $0.79. San Francisco estimated the clean-up cost for each littered plastic bag to be $0.052 (Pender, 2005; Burnett, 2013).

Litter also has an economic impact especially in coastal communities where tourism is a significant contribution to the local economy. Reduced tourism, especially beach visitations, from the aesthetic impacts of litter, can result in direct economic losses (Newman et al., 2015). An analysis of the economic impact of beach debris, which was found to be 78% plastic, was conducted during the three-month prime beach season for Orange County, CA. The analysis included the impact of reduced quality of a beach visits resulting in the cost to travel to an alternative beach or to choose another activity. The economic benefits of a 100% reduction in marine debris at the beaches was valued at $64.93 per visitor, a 75% reduction in beach debris was valued at $46.39 per visitor, 50% reduction was valued at $29.50 per visitor, and a 25% reduction was valued at $14.09 per visitor (Leggett et al., 2014).

2.3. Municipal options to reduce single-use consumer products

When distributed to customers as "free," single-use bags appear to be without cost to consumers who do not see the price and thus tend to engage in excessive consumption (Taylor and Villas-Boas, 2016). Consumers are conditioned through the repetitive action of receiving free bags thus becoming an automatic expectation and behavior within the shopping context (Ohtomo and Ohnuma, 2014). Thus, to eliminate or reduce consumption of single-use shopping bags, strategies to change consumer behavior are necessary. As discussed below, there are five major categories of strategies available to local governments to eliminate or reduce the consumption of single-use bags. Table 2 presents a summary of the primary strategies used by local governments including their positive and negative attributes.

Table 2
Summary of local government approaches to reduce single-use shopping bags.

Approach	Overview	Benefits	Negatives
Bans	Retailers are prohibited from providing plastic single-use bags	Most effective approach to reduce consumption and litter and easy to enforce	With bans, increased consumption of nonbanned bag will occur unless there is a fee on non-banned bag. Bans eliminate consumer choice. Bans on plastic bags means increased purchases of plastic garbage bags
Taxes and fees	Levies visible, separate fee on bags	Reduces consumption and litter. Fosters reuse. Fees kept by retailers can compensate for compliance costs or used to fund anti-litter programs. Relatively easy to enforce. Retains consumer choice	Increased cost to consumers and increased administrative cost for regulator and retailer. New taxes are generally unpopular
Specified bag design	Specification of minimum thickness, minimum post-consumer recycled content, use of sustainably grown materials, compostability, or inclusion of pro-environment message	Can reduce upstream environmental impacts. Can increase recycling and or composting opportunity at EOL	Very difficult to enforce. Increased costs to retailers depending on bag cost but does not by design reduce consumption or increase recycling
Consumer education	Educating consumers on reducing consumption or increase recycling	Low or no cost to consumers and does not imposes restrictions on consumers	Very difficult to enforce and expensive to implement and maintain. Not likely to have appreciable impact on consumption or recycling
Mandated retailer take back	Retailers required to provide consumers opportunity to return EOL plastic bags for recycling	Relies on voluntary actions of consumer to return bags. Low or no direct cost to consumers	Easy to enforce if only containers need to be provided. Could increase consumption of bags due to moral licensing effect. Increased cost to retailers

2.3.1. Bans

As described by Hodge and Scanlon (2014), local governments possess so called police powers, which allows them to ban products in specific situations involving public health and have been used, for example, to ban the sale of products (e.g., alcohol or tobacco) or restrict nuisance commercial or industrial activities through local zoning and licensing ordinances. Bans are highly effective in that they disrupt consumer behavior by eliminating choice (Carrigan et al., 2011). Bans, however, also tend to be

unpopular because they reduce consumer freedom (Coulter, 2009). However, in a study conducted by Sharp et al. (2010), in general, shoppers were resistant to the idea of a ban on plastic shopping bags, but post-implementation, became less resistant.

Bans generally prohibit retailers from offering single-use bags at the point of sale. The first city in the USA to ban plastic bags in large grocery stores and retailers was San Francisco in 2007. There are often exemptions from bag bans such as allowing paper bags, reusable bags, barrier bags for loose produce and meat, dry cleaning bags, bags for home delivered newspapers, and bags for carryout restaurants. Bag bans also can be broader. Seattle, WA, expanded its ban on single-use shopping bags starting in 2017 to include any green- or brown-tinted, non-compostable plastic bag for produce mandating that compostable bags, which are not banned, must be tinted green or brown (SPU, 2017). Taylor and Villas-Boas (2016) found that with a plastic only bag ban, some consumption shifts to reusable and paper bags. They found a significant increase in paper bags from about 5% prior to a ban to 46.5% after the ban. However, in stores that sell inexpensive reusable bags (i.e., $0.15), consumption of paper bags increased to only 10% (Taylor and Villas-Boas, 2016).

Although not the product of a direct ban, the State of Maine was the first state to adopt choice architecture as a means to reduce the consumption of single-use plastic bags statewide. Choice architecture seeks to alter consumer behavior without banning certain behaviors by encouraging a preferential selection (Thaler and Sunstein, 2008). In 1989, the Maine Legislature passed a bill that required retail establishments to offer only paper shopping bags at the point of sale unless the customer specifically requested plastic bags, which was a type of "soft ban" (Wagner, 2016). The law worked as intended and was highly successful in reducing the consumption of plastic bags: the law resulted in a decrease of 267 million plastic bags, but there was a corresponding increase of 254 million paper bags consumed resulting in the unintended, significant cost increase to retailers because of the higher price and higher demand of paper bags leading to the law's subsequent repeal (Wagner, 2016).

In Seattle, WA, a ban on plastic shopping bags, which excluded food-service establishments such as restaurants, coupled with a $0.05 fee on paper shopping bags, took effect in 2012. Based on waste characterizations, between 2010 and 2014, the amount of plastic bags in residential waste declined nearly 50% in spite of a 10% increase in the city's population (Hoffman, 2016). Based on a random sample of compliance inspections in Seattle, small and independent grocery and convenience stores had a lower compliance rate under the ban compared to drug stares and apparel stores (Hoffman, 2016). An unintended consequence of the ban was that when the ban became effective, some stores removed their in-store plastic bag collection stations for customers to recycle plastic bags resulting in an increase in plastic bags collected at curbside residential recycling (Hoffman, 2016).

2.3.2. Taxes and fees

The production and EOL management of single-use bags causes negative, unintended environmental impacts (environmental damages) that are not internalized into the price. One approach to reduce the environmental impacts is to increase the cost by increasing the price with taxes or fees, which is based on the polluter pays principle. In essence, taxes and fees are a de facto ban on free bags. Fees can be levied on all single-use bags or on specific bags such as plastic bags. Fees and taxes seek to modify consumer behavior as opposed to a ban, which seeks to regulate behavior.

Fees and taxes are generally levied at the point of sale and can promote cost internalization by the producer or retailer or if it is a separate, visible point-of-sale "eco-fee," the cost is internalized by the consumer (Bury, 2010). Thus, when a producer, retailer, or consumer is presented with a more accurate price signal that incorporates some or all costs from environmental damages (social costs), the cost will increase and consumption will decrease. Akullian et al. (2006) calculated the externalized cost of single use bags (paper and plastic), the cost borne by society as opposed to the producer, retailer, or consumer, to be $0.1052 per bag arguing that a fee based on a Pigovian tax should be at least $0.11. (Pigovian tax is the tax levied on a producer's activity when it causes negative environmental externalities. The tax is set to equal the social cost of the activity and is intended for the producer to internalize the social costs of the activity.) The City of Boulder, Colorado identified the appropriate per bag fee to be $0.198, which included the external costs, administrative and retailer costs, and solid waste management costs (Brendle, 2012). Similarly, San Francisco provided a rough estimate of the per plastic bag externalized cost at $0.17 in 2004 (Pender, 2005; Burnett, 2013). The $0.17 cost was composed of the following: contamination of recycling stream ($0.014), contamination of compostables ($0.008), collection and disposal of bags ($0.072), litter clean up ($0.052), and processing in landfills ($0.024) (Burnett, 2013).

As noted by Romer and Tamminen (2014), many local governments cannot levy a tax, which is a national or state prerogative, but they can levy user or impact fees. As suggested by Muralidharan and Sheehan (2016), single-use shopping bag ordinances framed as a tax maybe more effective than a fee because messages framed as a loss, as in the payment of the tax, can be more effective at promoting environmentally sustainable behavior. This loss aversion response was seen in South African consumers where individuals preferred avoiding a loss rather than acquiring an equivalent gain (Dikgang et al., 2012). This behavioral response to a fee was also found by Homonoff (2013) who found that charging a fee is more effective at reducing point-of-sale consumption compared to offering a bonus or credit as a reward when the consumer does not receive a single-use bag. According to Rivers et al. (2017), levying a very small, but separate and visible fee on single-use bags is a nudge, which is a form of choice architecture that does not regulate a behavior, but seeks to guide a preferred behavior, which in this case is to avoid a bag.

The first bag tax was initiated by Ireland in 2002. Ireland levied a €0.15 tax on plastic bags at the point of sale with the explicit goal of changing consumer behavior to decrease the demand for single-use plastic bags (Convery et al., 2007). The initial reduction in per capita plastic bag consumption was 90% from 328 to 21 bags per year (Rucker et al., 2008). Subsequently, annual per capita consumption increased to 31 plastic bags, the "rebound effect," prompting an increase in the per-bag tax to €0.22 (Rucker et al., 2008). The rebound effect also was observed in South Africa in which the imposition of a fee on plastic bags initially reduced consumption but consumption steadily increased over time in part to a lowering of fees (Dikgang et al., 2012).

Homonoff (2013) found that in Montgomery County, MD, which imposed a $0.05 fee on all single-use bags, prior to the tax, 82% percent of customers used at least one disposable bag per trip whereas after the tax, 40% used at least one disposable bag. Based on a post-tax survey of businesses in Washington, DC, 79% of businesses surveyed reported that on average they were providing fewer bags since the tax and the mean reduction in total number of bags distributed on average for each business was self-reported as 47% (OpinionWorks, 2013). In Victoria, Australia, during a two-month trial period in 2008, a voluntary $0.10 levy imposed on plastic shopping carry bags resulted in a 79% decrease in plastic bags provided by participating grocery stores (Lewis et al., 2010). As reported by survey respondents in Portugal, the country's plastic bag tax reduced the number of plastics bags consumed from 2.25 to 0.59 plastic bags per person per shopping trip (Martinho et al., 2017). The authors also found that in response to Portugal's plastic

bag tax, survey respondents reported an increase in the reuse of plastics bags; however, the authors found that survey respondents reported a 12% increase in the purchase of plastic garbage bags after the plastic bag tax (Martinho et al., 2017).

Following the adoption of a ban on plastic bags combined with a $0.05 fee on paper bags, in Los Angeles County, no plastic bags were distributed by the covered 72 retail establishments but there was only a 16% decrease in paper bag usage (LA County, 2012). Taylor and Villas-Boas (2016) found that in stores with a plastic ban coupled with a fee for paper bags, about 47% of customers brought reusable bags and about 30% brought disposable bags to reuse. In Santa Barbara, CA, following the imposition of a $0.10 fee on single-use paper bags coupled with a ban on plastic bags, total consumption of bags decreased by 89.3% (City of Santa Barbara, 2016). Following the imposition of a $0.10 fee in San Mateo, CA, on all paper or reusable bags, and a ban on free single-use plastic bags, there was a 161.5% increase in shoppers busing reusable bags, a 130.4% increase in the number of shoppers not using any bag, and a 65.8% decrease in number of shoppers using allowable plastics bags (San Mateo County, 2014).

Luís and Spínola's (2010) study in Portugal compared bag consumption habits between grocery stores that voluntarily adopted a bag fee and those that did not. They found that shoppers charged for plastic bags in grocery stores in Portugal, in this case €0.02 per bag, had significantly different behavioral responses compared to shoppers not charged a fee. For shoppers charged the €0.02 fee, 12% declined the bags compared to only 5% who declined bags when there was no bag fee. Similarly, 37% of the shoppers reused bags when faced with the fee compared to 0% for those not being charged. Finally, the authors found substantially higher utilization of the bag volume when facing a fee: 52% of the shoppers charged a fee maximized the volume of the bag with contents whereas only 17% of those who were not charged maximized the volume of the bag (Luís and Spínola, 2010) and thus reducing total bag consumption. Cain and Oke (2008) found similar results in Australia based on surveys. They found that in stores without bag fees, 13% of transactions involved a reusable carry bag and 15% of transactions did not involve a bag. In contrast, at stores that charged a fee for providing single-use bags, 33% of transactions involved a reusable bag and in 40% of transactions no bags were involved (Cain and Oke, 2008).

An increasing challenge to charging bag fees, and thus achieving the desired results of reduced bag consumption, is the dramatic rise of self service checkout technology for customers, especially in grocery stores, the largest provider of single use bags. In 1999, only 6% of supermarkets in the USA offered self-checkout compared to 95% in 2007 (Orel and Kara, 2014). Self service checkout lanes can create opportunities for malicious shoplifting (intentional) and non-malicious shoplifting (unintentional) by customers that are generally honest, but engage in theft when using self-checkout systems (Taylor, 2016). In addition, there are defiant customers; those who do not support the imposition of fees or taxes on bags and would refuse to pay as a protest as opposed to intentional theft. Given that a customer at a self checkout kiosk has to specifically indicate the number of bags used, and then pay the appropriate fee, there is temptation for the intentional or unintentional theft of bags to avoid fees.

2.3.3. Specified bag design

Specifying the type of bag that may be offered for free, subject to fees or taxes, or that is considered to be more environmentally preferable does not reduce the consumption of bags, but can potentially reduce the environmental impacts of the bags consumed. For example, a minimum thickness for plastic bags (to encourage the reuse of thicker bags), a requirement that reusable bags are machine washable, a minimum post-consumer recycled content for paper or plastic bags, and sustainable forest practices for paper bags are intended to reduce the environmental impacts of bags. Bags can also be required to have pro-environment messages imprinted regarding litter prevention, reuse, and recyclability.

As noted by Romer and Tamminen (2014), reusable plastic bags in the USA have been defined as 2.25 mm, which originated in California's plastic bag recycling law. This original standard created a de facto definition of reusable plastic bags as those greater than 2.25 mm. However, there are examples where the inclusion of the 2.25 mm standard has resulted in negative unintended consequences. For example, Honolulu County, Hawaii, banned single-use plastic bags in 2015 and defined reusable bags to include plastic bags that are at least 2.25 mm thick. Following the ban, stores proceeded to distribute for free, plastic bags that were 2.25 mm thick imprinted with the words reusable allowing them to circumvent the requirements resulting in the opposite of the intent of the ordinance (Soloman, 2016). This same practice occurred in Barrington, RI, following its 2013 ban on free plastic bags at checkout that were less than 2.25 mm. A revision to the ordinance was deemed necessary in which the 2.25 mm standard was removed resulting in a ban of all free plastic bags. Local ordinances increasingly have been establishing 4 mm as the minimum for a reusable plastic bag. Another frequent component has been the inclusion of a durability provision within a definition of reusable to include, for example, standards covering the minimum expected lifetime based on a minimum number of expected uses, minimum volume capacity, and minimum strength based on a minimum amount of weight to be carried a set distance (Romer and Tammin, 2014).

2.3.4. Consumer education

Education is traditionally seen as the first-step in seeking to achieve reductions in bag use or increasing recycling. Education is designed to provide tailored information and to maintain periodic dissemination of information to foster and support either source reduction (e.g., to use reusable bags) or to recycle at EOL. Education is done through written and social messaging, visual cues/prompts, and campaigns supported by the local government, retailers, community groups, or a combination thereof. To foster reduction, education can also focus on the negative aspects of single-use bags including litter prevention, reduced consumption, and/or contamination avoidance of bags. More important than standard, passive education through, for example, posting signs or notices, community-based social marketing designed specifically to change behavior is essential to counter the habitualized expectation of receiving free shopping bags by creating a bag-free norm (Sharp et al., 2010). For example, in an observational study by De Groot et al. (2013), a message combining an injunctive normative message (actions approved or disapproved by others) with a personal normative message (what people do) had a slightly greater impact on consumers reducing their consumption of free plastic bags at a supermarket checkout compared to a pro-environment message. Educational programs also rely on visible prompts to remind customers to bring their reusable bag.

Programs that rely on "bring your bag" educational campaigns to increase the use of reusable bags generally have had limited efficacy in source reduction due to the nature of shoppers. According to Sharp et al. (2010), voluntary actions by shoppers to reduce the consumption of single-use, store-provided bags is low especially given that shoppers' expectation of receiving free bags is entrenched and habitual. The case of reusable bags is interesting in that research has shown there is reduced male participation in environmental actions viewed as more feminine, suggesting males who shop are more likely to prefer single-use rather than reusable bags, which are considered feminine (Brough et al., 2016; Sharp et al., 2010). This is significant because of the role of men as shop-

pers in the USA; 79% of all adult men in the USA are categorized as significant grocery shoppers, defined as responsible for at least 50% of the grocery shopping, in their households and is continuing increase (FMI, 2016). Karmarkar and Bollinger (2015) found that shoppers who brought their own reusable bags increased their purchase of organic foods, but because of moral licensing, also increased their purchase of so called indulgent foods (e.g., "junk food).

2.3.5. Mandated retailer take back

Mandated retailer take-back is an approach that requires retailers offering single-use plastic bags to provide free and convenient opportunities for customers to return them for recycling. Retail take back programs have been shown to significantly increase convenience for customers because of the dramatic increase in locations available to drop off materials thereby increasing the collection of waste (Wagner et al., 2013). Multiple USA states have enacted laws requiring retailers that distribute single-use plastics bag to provide free collection of EOL plastics bags for recycling including California, Delaware, District of Columbia, Maine, New York, and Rhode Island. Effective in 2007, California enacted a law requiring all supermarkets, defined as grocery stores with more than $2 million in annual sales, and retail businesses of at least 10,000 ft^2 with a licensed pharmacy, to establish a plastic carryout bag recycling program at each store. However, in spite of California's law mandating that large grocery stores and retail establishments provide a free, in-store plastic bag recycling program, the state estimated the 2009 statewide plastic bag recycling rate to be only 3% (CalRecycle, 2010). As observed by Warner (2009), only providing for recycling does little to affect consumer behavior at checkout regarding consumption of single-use bags. Offering recycling has been shown to actually increase the consumption of items offered for free through the moral licensing effect making consumption more acceptable (Catlin and Wang, 2013; Sun and Trudel, 2017). In certain situations, offering recycling for a free consumer good (e.g., shopping bags) can undermine the goal of source reduction because consumers who recycle perceive that they are engaging in a pro-environment behavior (Catlin and Wang, 2013).

According to McLaughlin (2016), a retailer take-back program for plastic bags was implemented in Phoenix in part to reduce contamination and equipment downtime at the MRF resulting from plastic bags collected during curbside collection. In response to the program, plastic shopping bag consumption at retailers dropped by 12% and there was a 20% decline in plastic bags entering the MRF (McLaughlin, 2016). A variation is the approach taken by the City of Madison, WI, which passed an mandatory plastic film recycling ordinance requiring residents to recycle clean, segregated plastic bags and set then at curbside or drop-off them off at a recycling collection point.

3. Examination of local bag ordinances in the USA

As observed by Clapp and Swanston (2009), there has been a remarkable shift in the public's attitude toward plastic bags from harmless convenience to environmental scourge resulting in the enactment of several local bans and restrictions. The result, as the authors argue, is the emergence of an anti-plastic bag norm. Bans and reductions of single use bags are feasible because of the prevalence of alternatives, which include, for example, the no-bag-option when only a few items are purchased, starch-based polymer biodegradable bags derived from corn, and reusable bags including natural fiber bags (e.g., cotton, jute, canvas, bamboo, and hemp) and non-woven polypropylene bags. As discussed previously, there are a multitude of approaches to reduce single-use bags. Table 3 presents specific examples of local ordinances enacted to reduce single-use bags through bans, fees and taxes, specified bag design, consumer education, and mandated retailer take back.

Table 3
Examples of local government approaches to reduce single-use shopping bags.

Approach	Examples
Bans	- San Francisco, CA: Banned distribution of non-compostable plastic bags - Corpus Christie, TX: Plastic checkout bags prohibited at any city facility, city-sponsored event, or any event held on city property - NE Coastal NC Counties: Plastic bags banned at retail chains with 5 or more stores in the state or at stores with 5000 ft2 or more retail space - Palo Alto, CA: Banned plastic bags only at grocery stores - Westport, CT: Banned plastic bags, excluding produce bags and plastic bags, 28 in x 36 in or larger, at all retail stores except for non-profit stores
Taxes and fees	- Brownsville, TX: Free single-use plastic bags prohibited. Customer can pay $1 fee per transaction if plastic or non-renewable bags requested - Glendale, CA: All paper shopping bags subject to a 10¢ fee except for low income residents receiving benefits from the WIC (Women, Infants and Children) and SNAP (Supplemental Nutrition Assistance Program) who are exempt from the bag fee - Minneapolis, MN: Retail establishments providing allowable bags must charge customers at least 5¢ per bag. Retailers may choose to pay 5¢ bag to litter cleanup nonprofit in lieu of charging fee to customer - Montgomery County, MD: All bags subject to a 5¢ tax, which must appear on receipt. Retailer required to remit taxes to county only if cumulative amount of taxes collected exceeds $100 - Portland, ME: All bags subject to a 5¢ fee, all fees kept by the retailer
Specified bag design	- Seattle, WA: All compostable produce bags provided to customers by retailers must be tinted green or brown and must be labeled compostable - Carbondale, CO: Reusable bags, allowed and not subject to the 20¢ paper-bag fee, defined as a bag specifically intended for multiple reuse and made of cloth, fiber, or other machine washable fabric, at least 2.25 mil thick, minimum life of >75 uses, and can carry > 18 lbs - Washington, DC: Plastics bags must be 100% recyclable and paper bags must contain 40% post-consumer recycled content. Bags also must be imprinted with "Please Recycle This Bag" or substantially similar phrase. All bags subject to 5¢ fee - Cambridge, MA: Reusable bags defined as a plastic bag with handles and at least 3.0 mils thick, reusable paper bags must be 100% recyclable and contains at least 40% post-consumer recycled imprinting this information on the bag, and compostable bags must be certified as such by the Biodegradable Products Institute (BPI)
Consumer education	- Melbourne Beach, FL: City council proclamation for the voluntary program to reduce distribution and use of plastic bags - Vancouver, WA: "Recycle Wrap/Beyond Bags" education campaign to reduce and recycle use plastic bags - Eau Claire, WI: Adopted a phased approach. If the Education Phase after two years does not achieve a 45% reduction in single-use bags the Incentive Phase would be implemented and if the goal still not reached within one year the Requirement Phase will be implemented
Mandated retailer take back	- Chicago, IL: Stores required to collect and recycle plastic bags, provided bags must be imprinted with recycling message, and reusable bags must be offered for sale

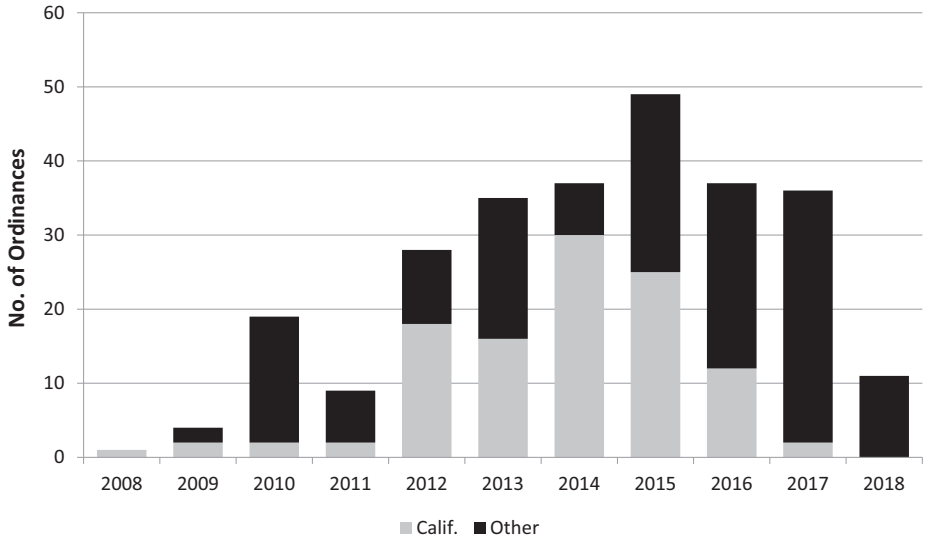

Fig. 1. Number of local single-use bag ordinances in the USA by effective date, 2008–2018. The figure does not include 5 ordinances that were enacted between 1990 and 2007.

As of September 2017, there were 271 local government ordinances specifically banning and/or taxing (or levying of fees) single use bags in the USA, which include the local ordinances enacted in California prior to the 2016 state law. These do not include the various ordinances enacted by local governments to promote voluntary reduction in bags through education, mandated bag design, or retail take back programs. Currently, 15.6% of the USA population lives in a jurisdiction with a local ban and/or tax/fee ordinance (or state law in California). The median size of local governments enacting a bag ordinance, excluding New York City,[1] was 23,233.

While the first plastic bag ban was adopted by Nantucket, MA, in 1990, followed by 4 other ordinances in the USA, it was not until after San Francisco's plastic bag ban in 2007 (this was in response to state-law that prohibited local fees on plastic bags) that bag ordinances began to be enacted in rapid succession. Currently there are bag ordinances in 24 states (including the District of Columbia). As shown in Fig. 1, the number of ordinances began to increase significantly in 2012. The graph tracks ordinances by the effective date of the ordinance and not the adoption date. In addition, the graph depicts the total number of ordinances by year and separates out California from other, which are local government outside of California.

Of the 271 local ordinances, 94% banned plastic bags and 6% levied a fee on all single-use bags (paper and plastic) without a ban. Of the ordinances that banned plastic bags, 57.6% also included a fee on paper bags. For all ordinances that levied a fee/tax on bags, the mode was $0.10 per bag. Of all the fee/tax ordinances, only two used the term tax, and all fee/tax-based ordinances allow the retailer to keep all or part of the collected funds. The term used by local governments for fees/taxes vary including Advanced Recovery Fee, Environmental Fee, Disposable Bag Fee, Disposable Paper Bag Fee, Waste Reduction Fee, Carryout Bag Tax, and Checkout Bag Tax. One municipality, Brownsville, TX, previously charged a $1 environmental fee for each retail transaction when plastic bags were provided, but the fee was repealed in January 2017 due to Texas' statewide prohibition on local governments from restricting shopping bags.

[1] New York City, with a population of 8,550,405, enacted its Carryout Bag Law in 2016, which mandated a fee of $0.05 on all single use bags. In February 2017, the State of New York enacted a moratorium on New York City's law pending the outcome of a task force report.

The most common ordinance has been a ban on plastic bags coupled with a fee on paper bags, this approach was not originally adopted because it was viewed as the most effective policy, but as a result of the unintended consequence of California state law, which prohibited fees on plastic bags but did not address paper bags. Thus, prior the adoption of California's state law in November 2016, 90% of California's local ordinances adopted a ban on plastic and a fee on paper (or paper and reusable). The other 10% of ordinances in California adopted a ban on plastic shopping bags, but did not adopt a fee on paper or reusable bags.

4. Conclusion

Because of their ubiquitousness and limited recyclability, single-use bags present an economic issue to local governments because of the additional costs of plastic bag litter clean-up, the costs to protect and clean stormwater catchment basins, the potential economic impact of decreased tourism due to unsightly litter, and the costs from impacted sorting equipment at materials recovery facilities. Plastic bags are also an environmental problem because of marine litter.

As presented in this article, local governments in the USA have the most responsibility with regards to managing MSW, yet have limited authority to shift responsibility back onto the producer. As a result, local governments increasingly have adopted ordinances that embrace strategies seeking to reduce the consumption of single-use bags at the point of retail sale primarily by banning and levying of fees. Banning the distribution of free single-use plastic bags have become the most prevalent action especially for plastic bags. An additional popular approach is the imposition of fees, especially when coupled with a plastic bag ban, which has been shown to dramatically reduce the number of single-use bags consumed as customers increase the reuse of bags or increase their use of reusable bags, maximize the use of a bag's volume, or go without. Local government approaches focusing only on education or that mandate the opportunity for recycling though retailer take-back of used plastic bags does little to affect consumer behavior at checkout regarding their consumption of single-use bags (Warner, 2009). And, in fact, may inadvertently increase consumption through moral licensure (Catlin and Wang, 2013; Sun and Trudel, 2017). Also as discussed, ordinances that adopt choice architecture through, for example, fees or default bag choice, must

pay careful attention to potentially negative unintended consequences as restricting one type of product can shift the consumption of an environmentally less desirable and/or more expensive product. Finally, in spite of the economic and environmental benefits of eliminating or banning bags, there must be recognition that an outcome of any of these ordinances could be increased costs to the consumer and/or retailer, decreased consumer choice, or decreased consumer convenience giving rise to resistance to local efforts. Local government actions have also given rise to state-level resistance as 11 states have enacted laws to restrict local governments from regulating shopping bags. Because of the success with single-use bags, local governments are also enacting similar ordinances on single-use expanded polystyrene consumer products and other single-use plastic products.

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